US Army Corps
of Engineers®
Engineer Research and
Development Center

Regional Morphology Analysis Package (RMAP): Part 1. Overview

PURPOSE

This Regional Sediment Management (RSM) Technical Note describes the Regional Morphology Analysis Package (RMAP), an integrated set of tools developed for manipulating, analyzing, visualizing, and archiving data on shoreline positions and beach profiles in a georeferenced environment on a personal computer. Information can be referenced to and displayed on aerial photographs and maps. Developed to support regional as well as local project studies, data types and analysis procedures are applicable to coasts, estuaries, and rivers. This technical note provides an overview of RMAP. Future technical notes in the RMAP series will describe specific features and new capabilities.

BACKGROUND

RMAP evolved from the Beach Morphology Analysis Package (BMAP) (Sommerfeld et al. 1993, 1994; Wise 1995), which was conceived to simplify and automate numerical modeling work flow and associated analysis of beach profile data and results of computations from the Storm-induced BEAch CHange model (SBEACH) (Larson and Kraus 1989; Larson, Kraus, and Byrnes 1990). Although BMAP provides a robust toolset for profile

20041109 066

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

analysis, it is limited to data in distance-elevation space. BMAP requires the user to discard the geospatial aspect of profile data, essential in data assembly and quality control. Regional analysis requires manipulation of another type of two-dimensional (2-D) data, the shoreline, which is georeferenced. Numerical simulation models under development in the Regional Sediment Management (RSM) Program involve manipulation of data and corresponding outputs in a georeferenced coordinate system, often over wide geographic areas and different coordinate systems. These and other U.S. Army Corps of Engineers' needs identified at a field-data collection workshop were the stimulus for creation of RMAP.

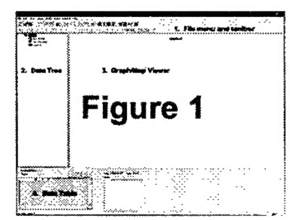
Typically, analysis of beach profile and shoreline position data requires several software packages. On the other hand, the engineering and numerical modeling work environment calls for tools directly supporting workflow from the original surveys to quality control, analysis, and input to a project report or model. RMAP contains a comprehensive set of analysis and visualization tools required for project workflow, from the import of raw data and coordinate conversion through detailed analysis to report-quality graphics. RMAP supports analysis of beach profile, channel or river cross-sectional data, and shoreline position data for engineering and science applications. Capabilities extend from generation of spatially referenced shoreline change maps to a large suite of beach profile analysis tools. Data can be examined in both cross-sectional and map views to simplify data assembly, quality control and assurance, data analysis, and generation of report

figures. The map viewer supports the display of profiles, shorelines, aerial imagery and ArcView® shapefiles in a geospatial environment. Data options allow storage, organization, and analysis of data in a single application, with support for a variety of import/export formats. Chart options allow tailoring of graphics to personal needs, supporting export of images and direct copy and paste into word processing software. Metadata can be stored at project, group, or individual data item levels. RMAP is backwards-compatible with BMAP project files and supports calculation of geographic coordinates from reduced distance-elevation data pairs.

This technical note summarizes present capabilities of the RMAP software. Planned work in the RSM Program will add routines to RMAP for analyzing and visualizing three-dimensional (3-D) (X, Y, Z) data, where X and Y denote horizontal coordinates, and Z denotes the vertical coordinate. In addition, the final version will include relational database capability to archive and access large data in space and time that are often encountered in RSM applications.

RMAP Interface

RMAP runs in the Microsoft Windows® environment and requires computer resources available on typical personal computers. The RMAP interface comprises four main features (Figure 1).



a. **File menu and toolbar.** Data import/export, analysis functions, and viewer controls are accessed through the file menu and toolbar.

b. **Data tree.** The data tree displays data items present in the software package and allows selection of multiple items for batch conversion or analysis.

c. **Graph/map viewer.** The graph/map view window supports visualization of data by cross section in graph mode and plan view in map mode.

d. **Data Table.** The data table allows the user to view and edit data for each item in the data tree. This area also stores the time stamp of the data entry and allows the user to store comments on each item in the data tree.

File menu and toolbar

The RMAP file menu provides access to functions common in Windows applications (such as *Save, Open*, etc.), and those functions unique to RMAP, such as graph controls, data grid functions and profile and shoreline analysis tools. Many functions can also be accessed from the RMAP toolbar, where they are grouped by functionality (Figure 2). Functions unique to RMAP are discussed here.

Figure 2

Items under the *File* menu support import/export of project data from ASCII text files or the RMAP free format. The RMAP free-format allows users to import entire data sets at once, or archive RMAP projects into an ASCII text file that can be accessed by spreadsheet applications or text viewers. The *Edit* menu allows access to data management functions for the data tree, project

options and settings. Multiple items in the data tree can be moved, copied or deleted using the item checkboxes and the command under the menu. Also, coordinate conversion for single or multiple items is performed here. For beach profiles, tools are provided to calculate distance D from the transect origin (X, Y to D) or to calculate geographic coordinates from a transect origin along an azimuth (D to X, Y). The project options dialogue allows the user to specify the project units, store project metadata and name the project. The *View* menu allows the user to toggle the toolbars, status bar, and data table on or off.

Items in the data tree can be sorted by date or name (alphanumeric). The *Group* menu allows the user to add or delete groups or data tree items. This is also accomplished by right-clicking the mouse in the data tree. The *Graph* menu accesses options for the graph control. The graph appearance is customizable by the user, including background colors, line colors, width, axes scaling, etc. This menu also allows the user to export beach profile data plotted in the graph view to SBEACH. Future export options will include output to the GENESIS and CASCADE models, and to the Sediment Budget Analysis System (SBAS). The *Table* menu allows the user to insert and delete rows in the data table, as well as write protecting data. The *Analysis* menu contains analysis tools and algorithms for beach profile and shoreline data. These tools are discussed in the following

paragraphs. Finally, the *Help* menu provides user support and access to documentation on the analysis routines.

Data tree

Data are managed and selected for analysis in the data tree. The data tree in RMAP displays and organizes project data into three categories: beach profiles, shorelines and baselines, each identified by a unique icon (Figure 3). Data can be brought into RMAP by importing from ASCII text or RMAP free format, copying and pasting from spreadsheet applications, converted from ArcView® shapefile format (shorelines and baselines only), or entered into the data table by the user. Data tree entries are generated and named automatically when importing profile, shoreline, or baseline data into RMAP from ASCII text. In copying and pasting data into RMAP, data tree entries must be created first and then renamed by the user.

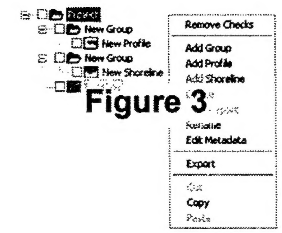


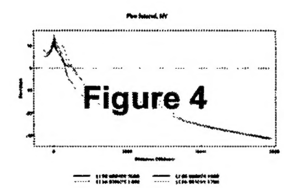
Figure 3

Items can be arranged into groups and subgroups under the *Project* menu. Data items can be sorted by date or name, or manually sorted by the user by dragging and dropping in desired order. Metadata settings include origin location and transect azimuth for profiles and definition for shorelines (e.g., as the high-water line (HWL), wetted bound, other; see Kraus and Rosati (1998)). A data item is plotted in the graph/map viewer and made available for analysis by activating the selection box beside the data type icon. The selection box also provides a means of copying, pasting,

moving, and deleting multiple data items in the tree. In addition, selection boxes are used to conduct analysis functions, coordinate conversion, and distance calculations for multiple items.

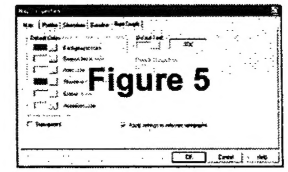
Graph/map viewer

The graph/map viewer provides visualization of both profile and shoreline data in graph (cross-section) or map (plan) views. The window is toggled between the two views by means of the RMAP toolbar (Figure 2). Data are plotted in the viewer by activating the selection box next to the item. In graph view, a typical cross-section plot is generated in the viewer (Figure 4). The plot legend is automatically generated on the plot as data are added. Plot axes adjust to the full extent of plotted data; however, the user can manually set the axis extent. The user can zoom into areas of interest and pan around the viewer to investigate data. Data values in the view automatically refresh as the data table is edited. The user has full control over graph appearance with the options available under the *Graph* menu.

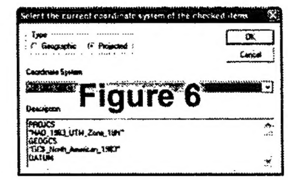


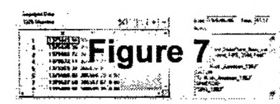
The map view allows visualization of spatially referenced profile, shoreline and baseline data, in addition to georeferenced aerial photography and ArcView® shapefiles. The ability to view data in plan view overlaid with ground imagery assists with data assembly, quality control, and data analysis. Each item is labeled according to the object name in the data tree as it is added to the view. Labels, feature items, and legends can be edited individually or as a group. The display properties of all items in the map view

can be customized to individual preferences in the map properties dialogue (Figure 5).



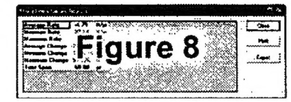
RMAP supports a variety of geographic and projected coordinate systems, including North American Datum (1927 and 1983), Geographic Coordinate Systems, U.S. State Plane, Universal Transverse Mercator, and World Geodetic System coordinates, in addition to many other systems in use worldwide. Units can be in either feet or meters. The user selects the project coordinate system in the map view properties; all data imported into RMAP can be then be converted to the project datum from within the application (Figure 6). Once the conversion is complete, the data table is refreshed with the new coordinates, and the conversion is recorded as metadata in the "Notes" section of the data table (Figure 7).

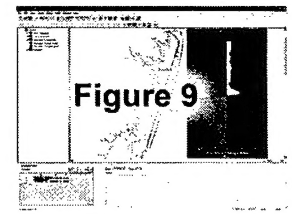


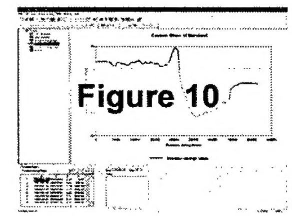


Shoreline analysis is directly supported in the map view. RMAP allows the user to calculate change rates between two shorelines from a user-defined baseline. Shoreline analysis transects are established perpendicular to the baseline at a user-specified interval, and then shoreline change and change rates can be calculated at each transect along the baseline. Shorelines and baselines can be imported from text, converted from ArcView® shapefiles, or drawn in the map viewer. Tools are provided to allow the user to annotate shoreline position on a photograph, creating a georeferenced shoreline entry in the data tree upon completion. After shoreline analysis is complete, RMAP

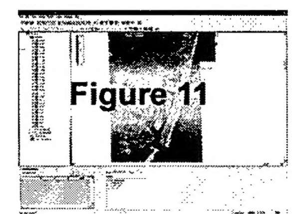
generates an analysis report (Figure 8), a spatially referenced shoreline change map (Figure 9), and a shoreline change rate plot in graph mode (Figure 10).

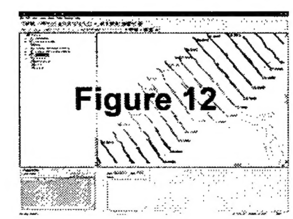






Profile data are also projected in the map view, simplifying the creation of base maps, easing data assembly, and streamlining quality control of data. As profile data are plotted, a color map elevation gradient is generated along the profile line to allow the user to distinguish shallow and deep portions of the profile (Figure 11). Profile overlap, distance off the transect azimuth, and the overall goodness of fit of the data are easily evaluated by switching back and forth between map and graph modes (Figure 12). Ready availability of map and graph modes makes convenient the translation or shifting of data, because results can be easily evaluated in both cross-section and plan views.





Data table

The data table allows the user to view and edit the time stamp, coordinate, elevation and distance values for each item in the data tree (Figure 13). A "Notes" Window is also provided to allow storage of metadata for individual items. Data in the grid are edited in a fashion similar to standard spreadsheet applications. Formats for the different data types are described in the following paragraphs.

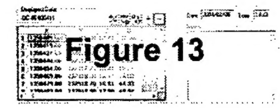


Figure 13

For beach profile data, the grid contains four columns: geographic horizontal coordinates (X and Y), elevation (Z), and distance (D). Tools are provided in the data grid for calculation of distances along the transect from the geographic coordinates, in addition to calculation of the geographic coordinates from distance elevation pairs given profile origin coordinates and transect azimuth. Consideration was given for accommodating BMAP project files while implementing RMAP coordinate capabilities. BMAP data columns (distance/elevation pairs) are automatically assigned to the Z and D columns upon opening. In addition, data are assigned to different columns depending on the number of columns present: pasting two columns places data in the D and Z columns; pasting three columns places data in the X, Y and Z columns; or pasting four columns places data X, Y, Z, and D columns. Shoreline and baseline data types have three data columns: geographic horizontal coordinates (X and Y) and elevation (Z), though in the case of baseline data, the Z column is not applicable.

Shoreline Analysis Tools

Shoreline change
Calculates shoreline change rates between two shorelines. Generates report including average, minimum and maximum change and change rates and time span of analysis. Generates shoreline change graph (graph mode) and a spatially referenced shoreline change map.

Shapefile convert
Converts ArcView® shapefiles into RMAP shoreline or baseline data items in the data tree.

Draw shoreline/baseline
Allows the user to digitize a georeferenced shoreline or baseline in the map viewer and creates a new item in the data tree.

Combine shoreline
Combines adjacent shoreline segments in order of increasing easting distance. Generates new entry in the data tree.

Interpolate shoreline
Resamples the shoreline at a user-specified interval and generates a new item in the data tree.

Smooth shoreline
Uses a running average of points to smooth a shoreline. User can specify number of points. Generates new entry in the data tree.

Mean shoreline

Calculates an average shoreline position for a series of selected shorelines, generates new item in the data tree.

Shoreline statistics

Calculates the number of points, variance, standard deviation, and minimum and maximum distances of a shoreline from the baseline.

Beach Profile Analysis Tools

RMAP includes a diverse set of tools for analyzing beach profile data. RMAP generates a report for each analysis, which can be exported as text, printed, or copied to the clipboard. Functions and analysis routines are described in the following text.

Bar properties

Bar properties are analyzed in RMAP by drawing a selection box around the bar form. Although defining a bar feature visually may be subjective, negligible differences in bar volume typically result from this method if done by an experienced user. Bar volume, length, center of mass, minimum depth and location, and maximum depth and location are reported.

Profile comparison

The profile comparison routine calculates the volume and contour location change for two profiles within a user-defined area.

Cut and fill

This routine compares two profiles and defines cells defined by intersections between the two profiles. The analysis report gives beginning and volume change is calculated for each cell. Total volume change, volume change above and below the vertical datum, and shoreline change at the datum are also calculated.

Horizontal alignment

The horizontal alignment routine translates profiles an arbitrary distance to horizontally align all selected profiles to the user-specified elevation contour.

Least square estimate

Estimates the A-parameter and median grain size (d_{50}) over a user-specified extent of a cross-sectional beach profile. Provides correlation coefficient (r^2) for the solution.

Volume and sectional volume

Calculates the volume of a beach profile above a user-specified elevation contour and/or to a user-specified spatial extent. Reports volume and contour location. The algorithm will interpolate profiles or modify analysis bounds if profile extent does not meet the analysis extent.

Transport rate

Calculates the cross-shore transport rates for a time period at user-specified interval between two succeeding profiles. Plots the

cross-shore transport rate and reports maximum and minimum rates, as well as the rate at the most seaward point of the pair or profiles.

Average

Calculates, plots, and generates new items under the data tree for the average, maximum and minimum profiles. The standard deviation for the analyzed profile is plotted on the graph.

Interpolate

Interpolates the profile at a user-specified interval. Generates a new profile under the data tree.

Translation

Allows the user to translate profiles vertically or horizontally (or both). Horizontal translations can be applied to the X and Y coordinates if the profile is in geographic space.

Combine profiles

Combines selected profiles. Profiles are selected using the check-box in the data tree, then combined in order of ascending distance or horizontal (X) coordinate values. A new profile is generated under the data tree upon completion.

Synthetic profiles

RMAP allows the user to generate several types of synthetic profiles, including beach-fill templates, equilibrium profile (Dean 1991) and modified equilibrium profile (Larson 1991), interpolated profiles, and plane sloping profiles.

Depth of closure calculation (Beach-fill module)

Estimates the depth of closure (Kraus, Larson, and Wise 1998) calculated by the Hallermeier (1978) equation for local significant wave height exceeded in a 12-hr interval, or through the mean annual significant wave height for a coastal area.

Erosion/accretion predictor (Beach-fill module)

Predicts erosion or accretion based on the sediment fall speed parameter for either deep water or finite depth based on equations in Kraus, Larson, and Kriebel (1991).

Planform evolution model (Beach-fill module)

The planform evolution model provides an estimate of the alongshore redistribution of beach nourishment material resulting from the interaction between the fill material and wave conditions at the fill site. The model embraces concept of background erosion in the prediction of shoreline change and has the capability to impose the effect of a user-specified rate of background erosion. Methodology is based on Dean and Grant (1989).

Product Development and Availablitiy

The RSM Program develops products to support engineers in the work force. Improvements or additions to RMAP are dependent on user comments. Please forward comments and suggestions to RMAP point of contact listed in the following section.

POINT OF CONTACT

This RSM Technical Note was written by Dr. Brian K. Batten, research physical scientist and by Dr. Nicholas C. Kraus, Senior Scientist, Coastal and Hydraulics Laboratory, Vicksburg, MS, U.S. Army Engineer Research and Development Center. The work described herein was supported by the National RSM Demonstration Program. Questions about this technical note can be addressed to Dr. Batten (601-634-4653, *Brian.K.Batten@erdc. usace army.mil*. Dr. Jack E. Davis (601-634-3006, *Jack.E.Davis@erdc. usace.army.mil*) and Ms. Julie D. Rosati (601-634-3005, *Julie.D.Rosati@erdc.usace.army.mil*) are RSM Program Managers. The RSM Web site (*http://www.wes.army.mil/rsm*) gives additional information.

REFERENCES

Dean, R. G. (1991). "Equilibrium beach profiles: Characteristics and applications," *Journal of Coastal Research* 7, 53-84.

Dean, R. G. and Grant, J. (1989). "Development of methodology for thirty-year shoreline projections in the vicinity of beach nourishment projects," UFL/COEL-89/026, Coastal and Oceanographic Engineering, University of Florida, Gainesville, FL.

Hallermeier, R. J. (1978). "Uses for a calculated limit depth to beach erosion," *Proceedings. 16th Coastal Engineering Conference*, American Society of Civil Engineers, 1493-1512.

Kraus, N. C., Larson, M., and Kriebel, D. L. (1991). "Evaluation of beach erosion and accretion predictors," *Proceedings Coastal Sediments '91*, American Society of Civil Engineers, 572-587.

Kraus, N. C., Larson, M, and Wise, R. A. (1998). "Depth of closure in beach-fill design," Coastal Engineering Technical Note CETN-II-40, U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory, Vicksburg, MS.

Kraus, N. C., and Rosati, J. D. (1998). "Interpretation of shoreline-position data for coastal engineering analysis," Coastal Engineering Technical Note CETN-II-39, U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory, Vicksburg, MS.

Larson, M. (1991). "Equilibrium profile of a beach with variable grain size," *Proceedings Coastal Sediments '87*, American Society of Civil Engineers, 905-919.

Larson, M., and Kraus, N. C. (1989). "SBEACH: Numerical model for simulating storm-induced beach change; Report 1: Empirical foundation and model development," Technical Report CERC-89-9, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Larson, M., Kraus, N. C., and Byrnes, M. R. (1990). "SBEACH: Numerical model for simulating storm-induced beach change; Report 2: Numerical formulation and model tests," Technical Report CERC-89-9, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Sommerfeld, B. G., Mason, J. M., Larson, M., and Kraus, N. C. (1993). "Beach morphology analysis package (BMAP)," *Beach Nourishment Engineering and Management Considerations, Proceedings Coastal Zone '93*, D. K. Stauble and N. C. Kraus, ed., American Society of Civil Engineers, 162-175.

Sommerfeld, B. G., Mason, J. M., Kraus, N. C., and Larson, M. (1994). "BFM: Beach fill module, Report 1: Beach morphology analysis package (BMAP) – User's guide," Instruction Report CERC-94-1, U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, Vicksburg, MS.

Wise, R. A. (1995). "Beach morphology analysis package (BMAP) version 1," Coastal Engineering Technical Note II-34. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

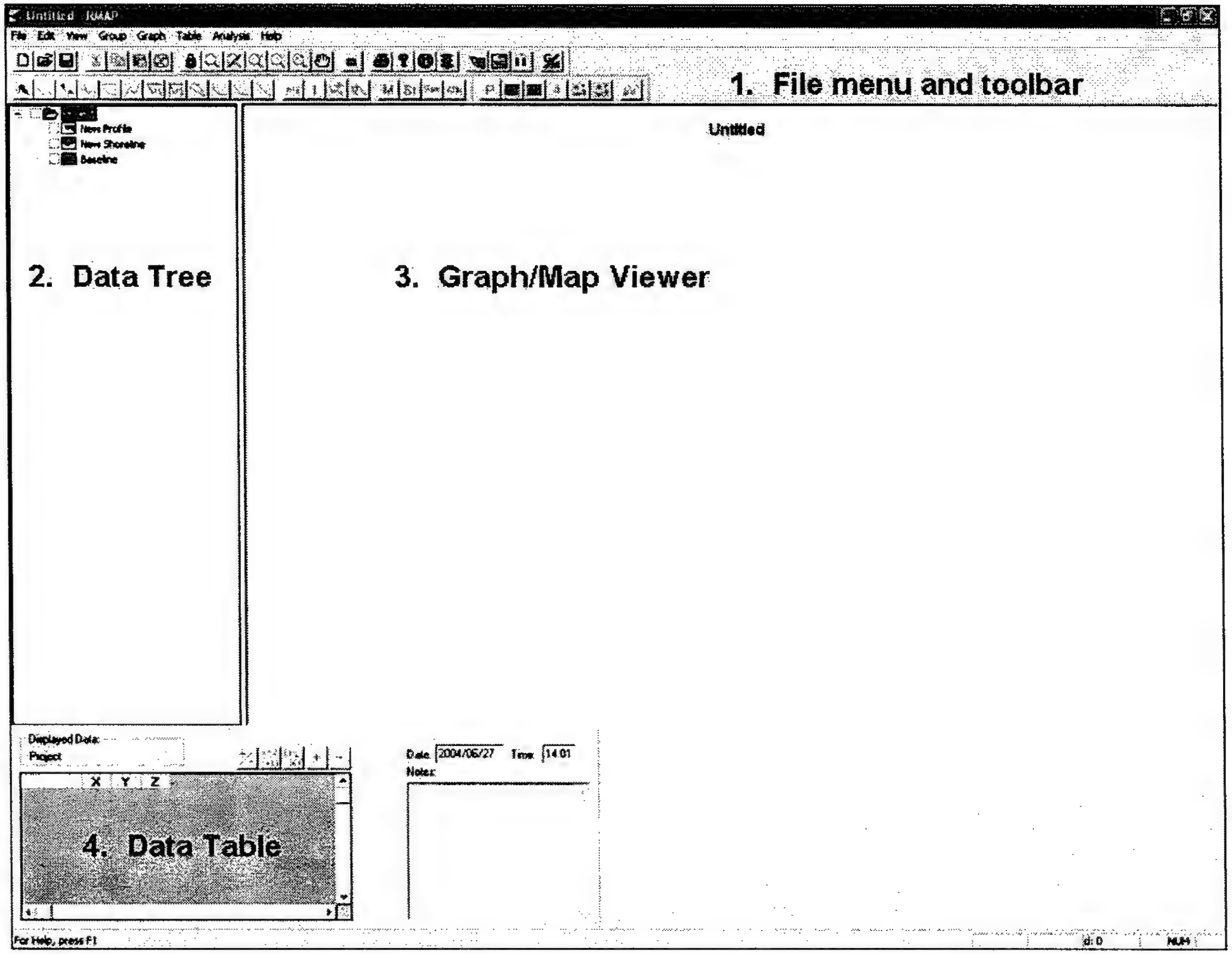


Figure 1. The RMAP interface is comprised of (1) file menu and toolbar, (2) data tree, (3) graph/map viewer, and (4) data table

back to text

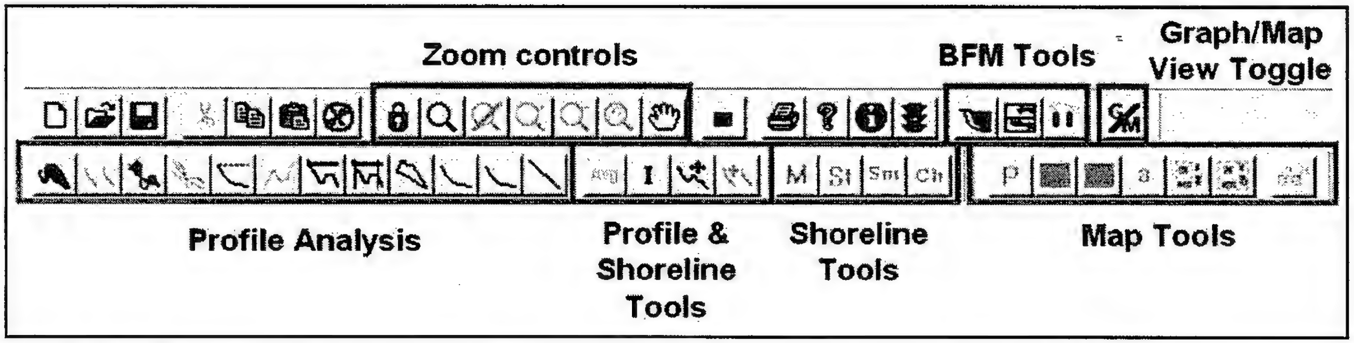


Figure 2. *RMAP toolbar is organized by file/program functions, zoom controls, Beach Fill Module tools, profile analysis, shared profile and shoreline tools, shoreline tools and analysis, and map tools*

back to text

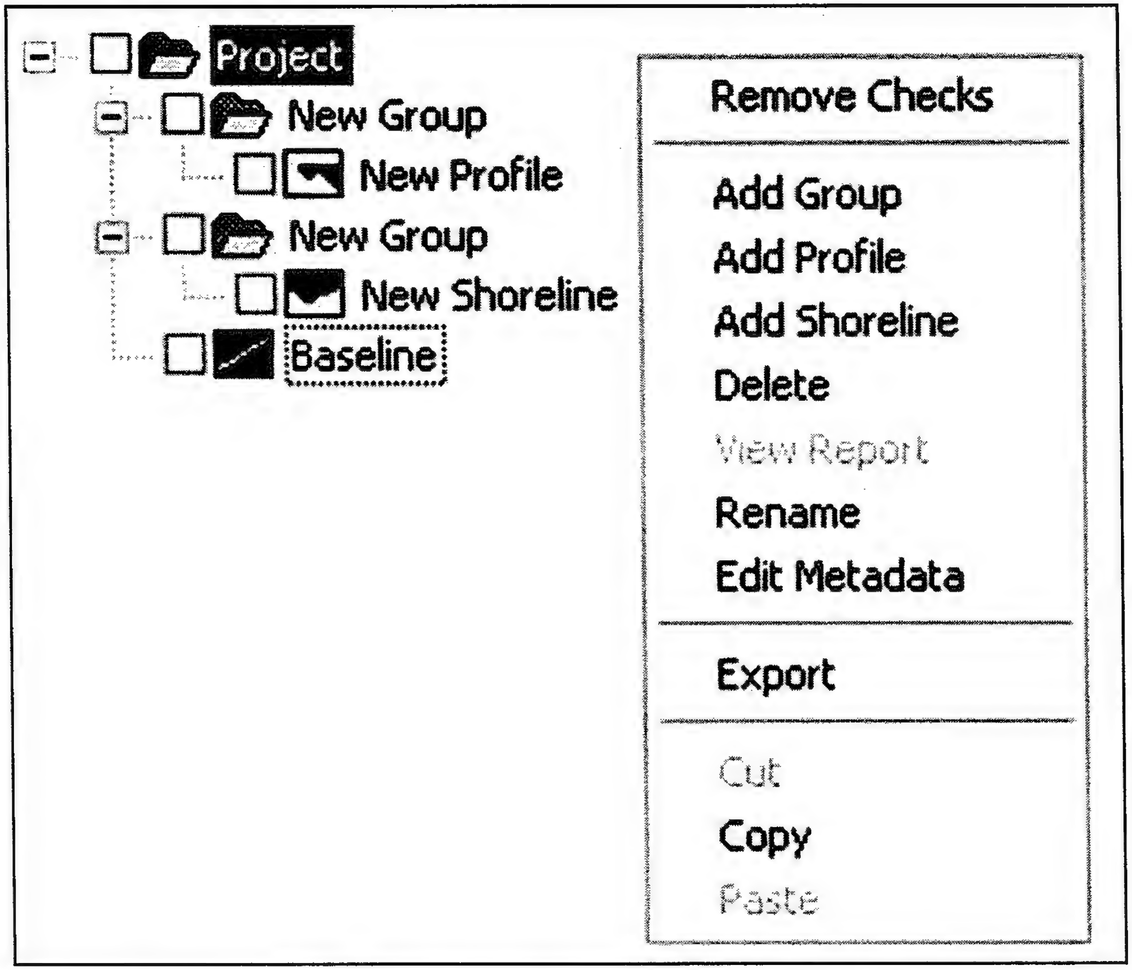


Figure 3. RMAP provides for three types of items in data tree: profiles, shorelines, and baselines. Unique icon in tree identifies each type

back to text

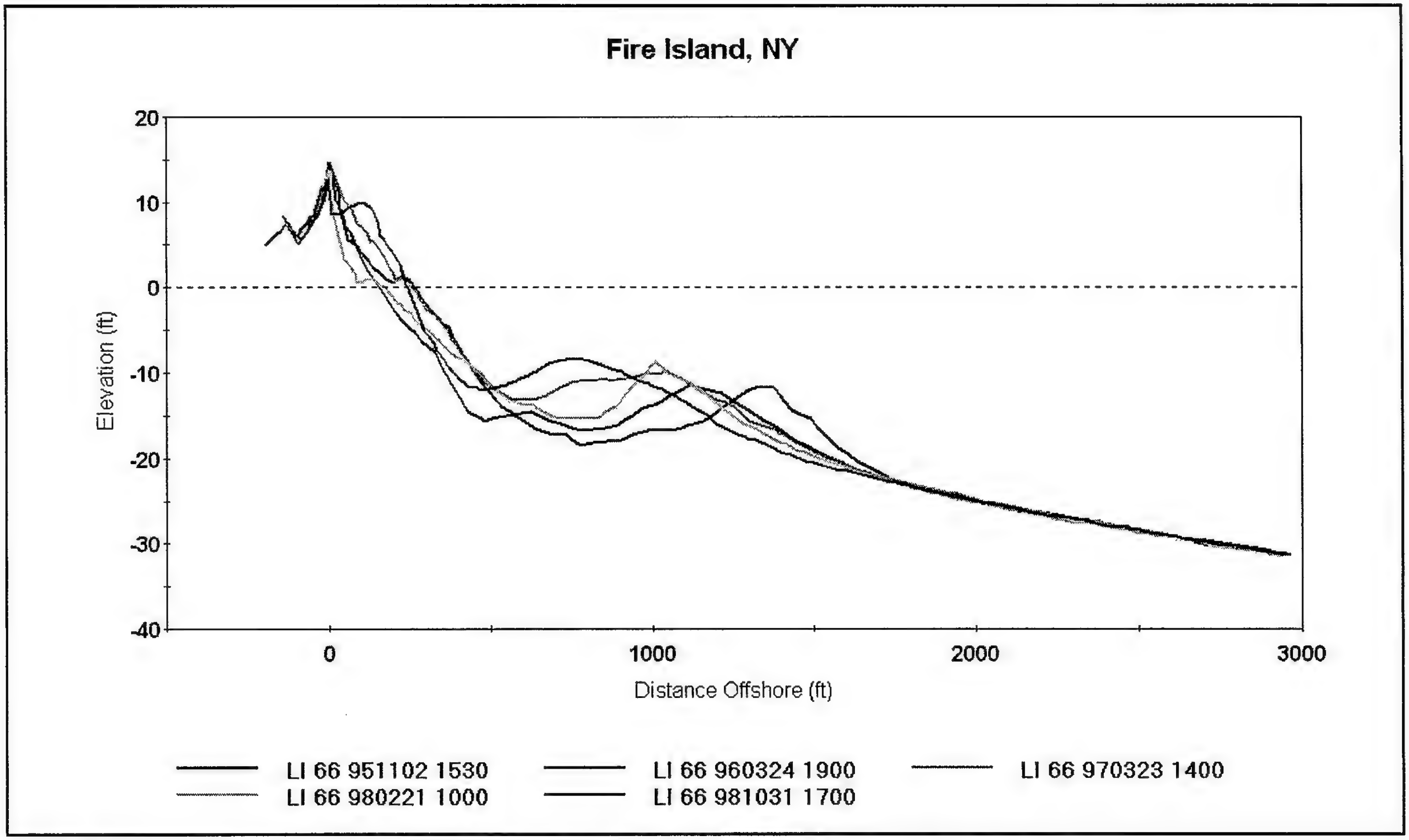


Figure 4. *Example of cross-section plot of beach profile data in RMAP. Data legend is generated automatically as data are added to plot. Plots can be copied directly from RMAP into word processing applications*

back to text

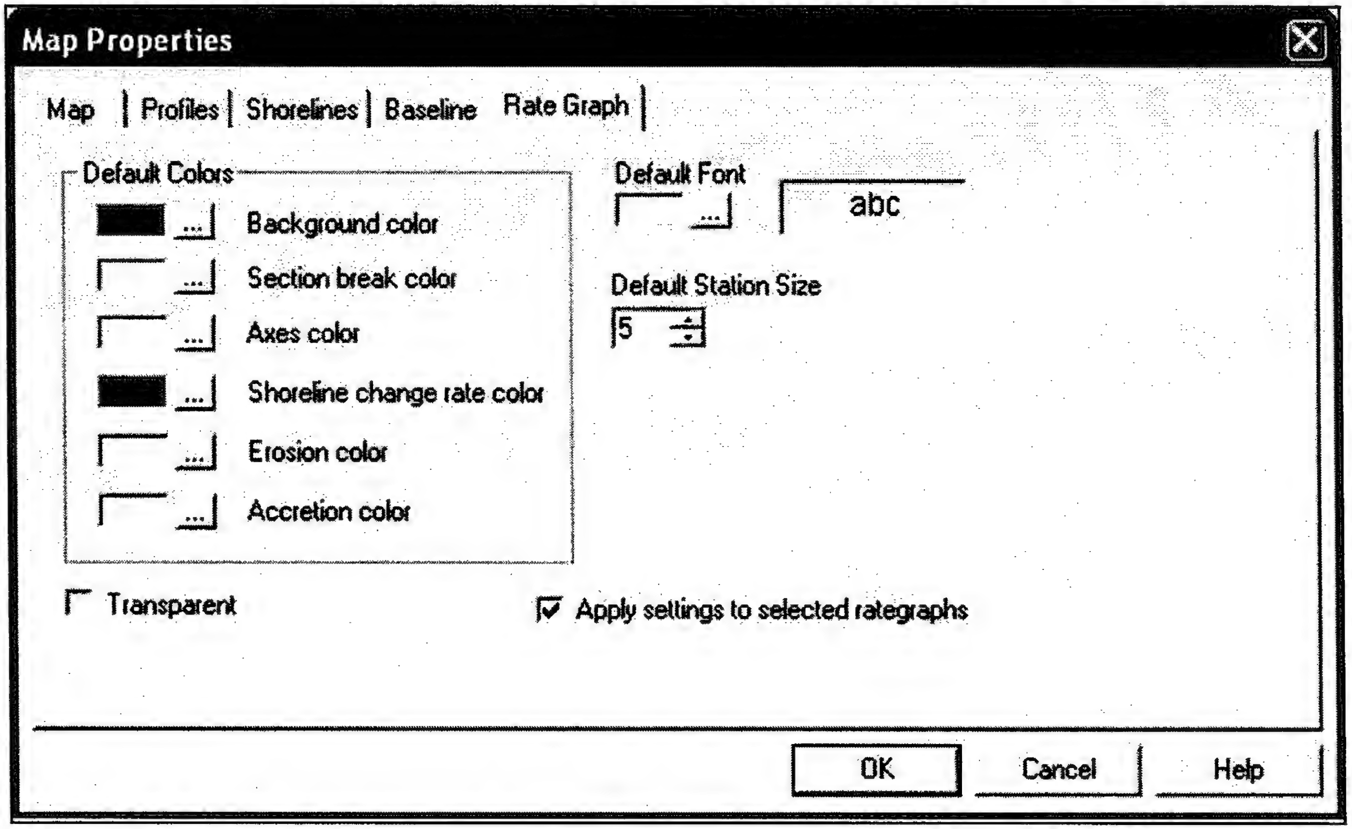


Figure 5. RMAP allows extensive customization of visual properties of all items featured in map view. Figure illustrates available options for shoreline change maps

back to text

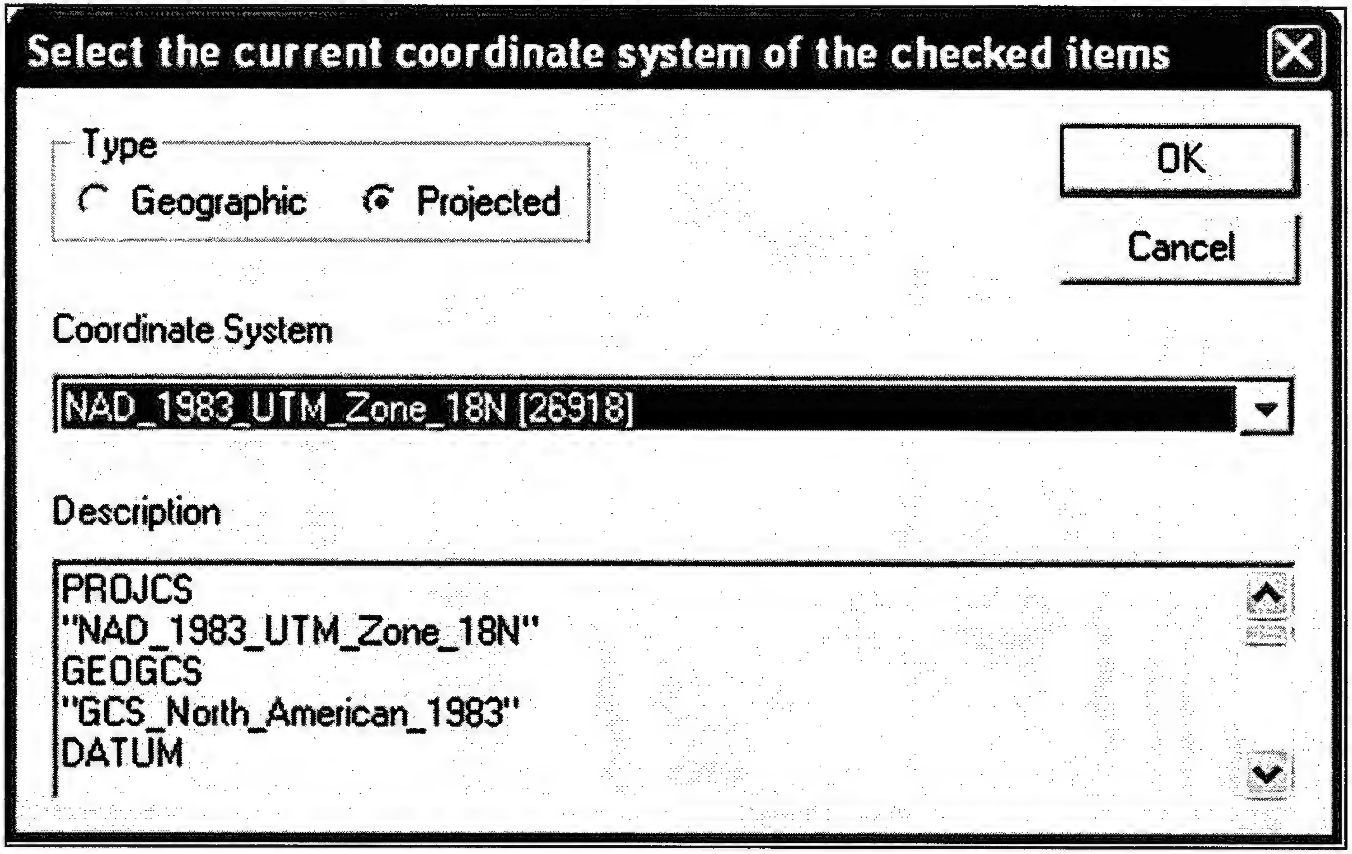


Figure 6. Beach profile, shoreline and baseline coordinates can be converted to project coordinate system within RMAP using coordinate conversion dialogue box

back to text

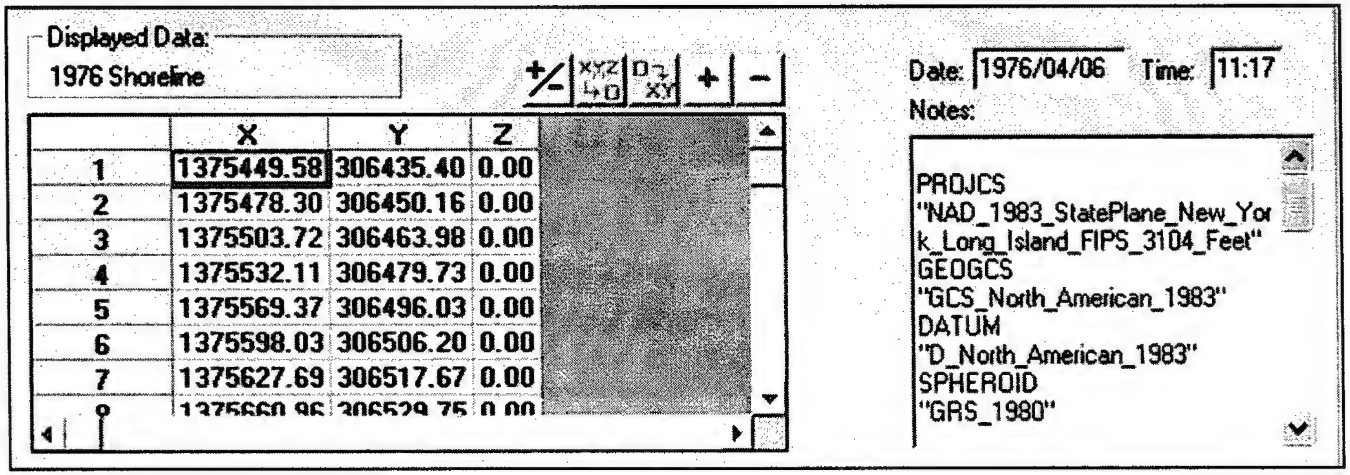


Figure 7. Coordinate conversions are recorded under items notes, located in data table

back to text

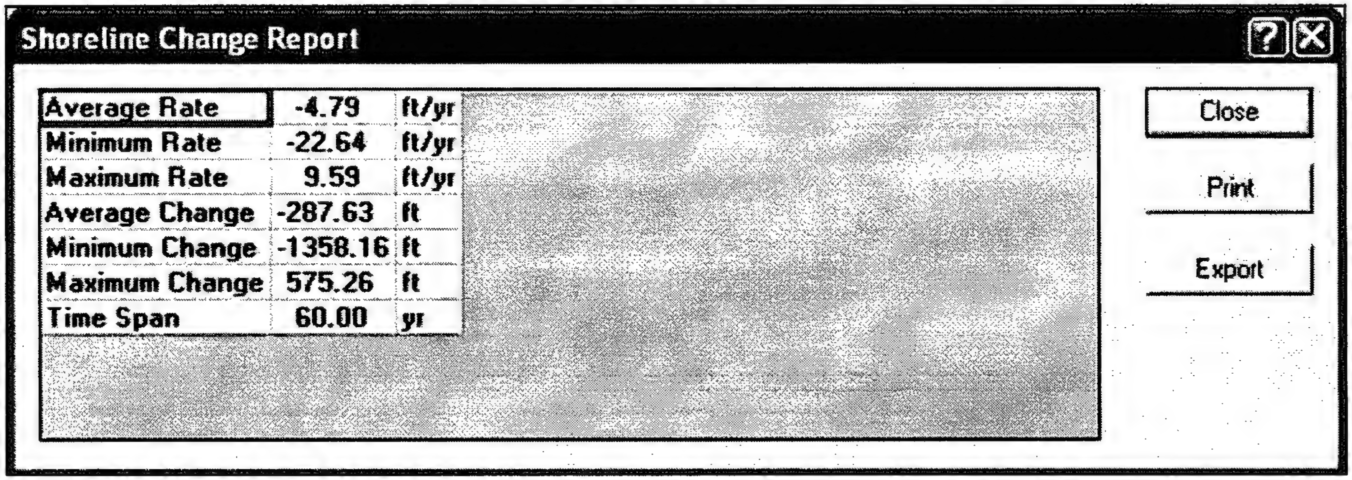


Figure 8. Shoreline change report. Average, minimum, and maximum shoreline change and change rates are given

back to text

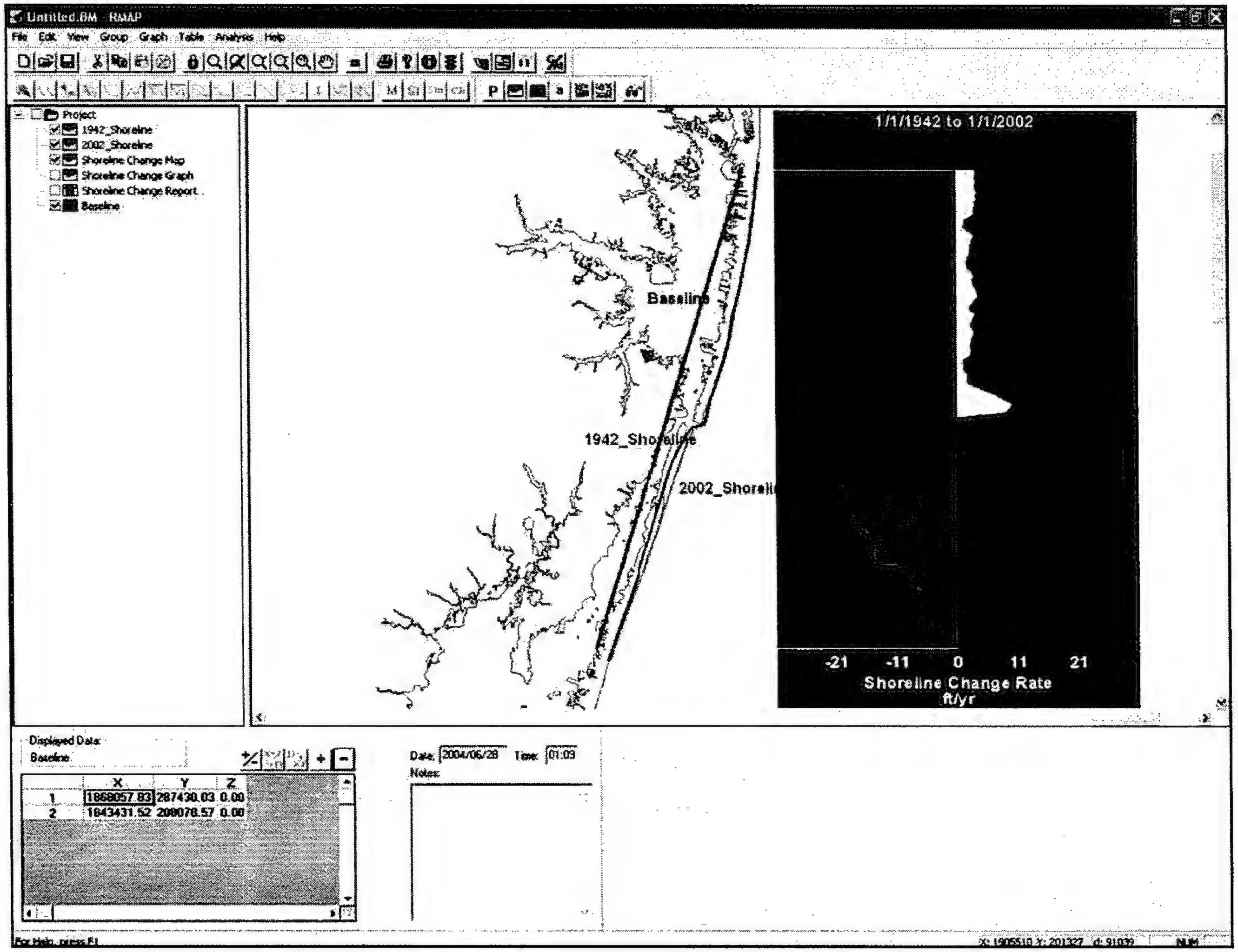


Figure 9. Spatially referenced shoreline change rate map for eastern shore of Maryland showing erosion downdrift of Ocean City Inlet

back to text

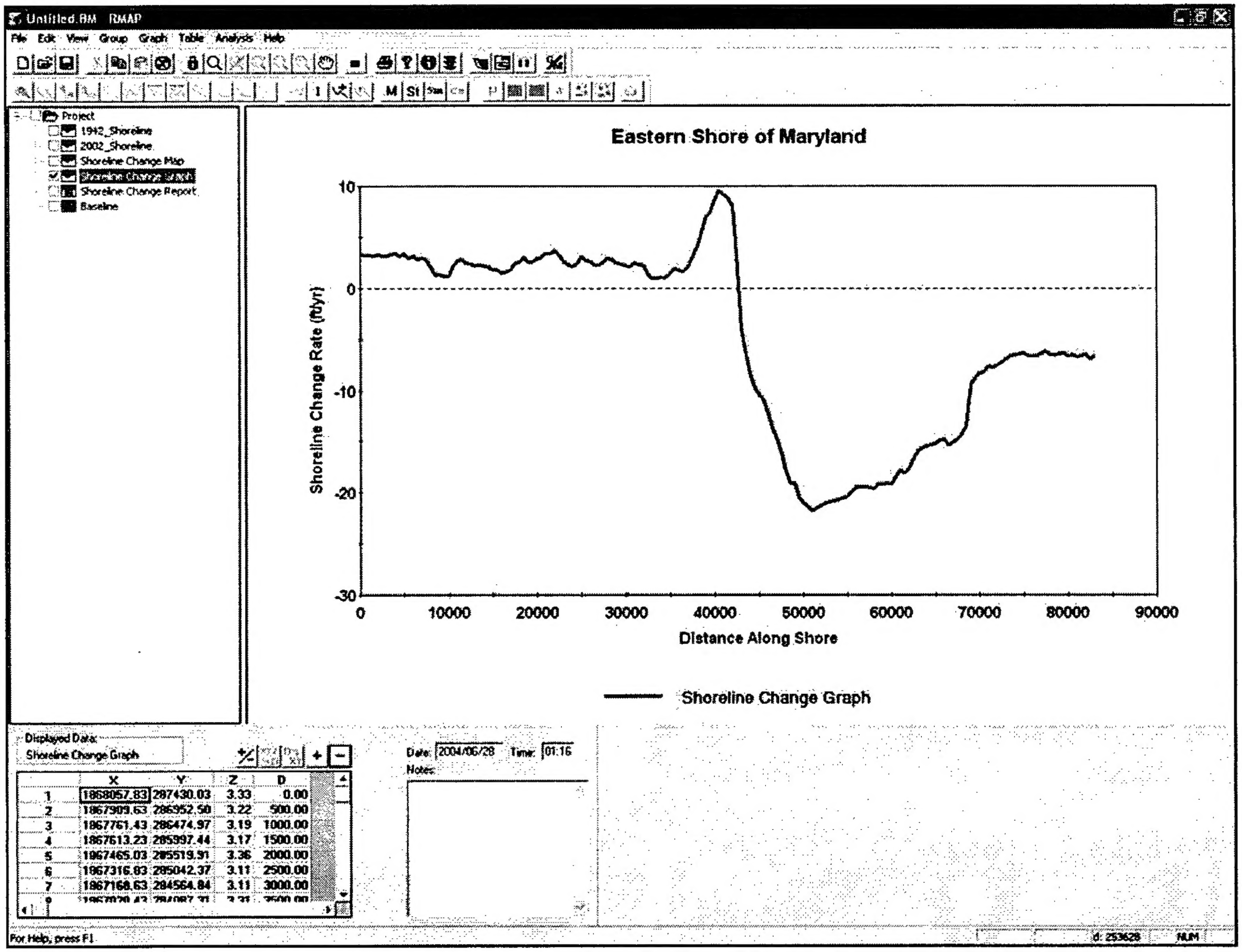


Figure 10. Traditional shoreline change rate plot is available in graph mode.

back to text

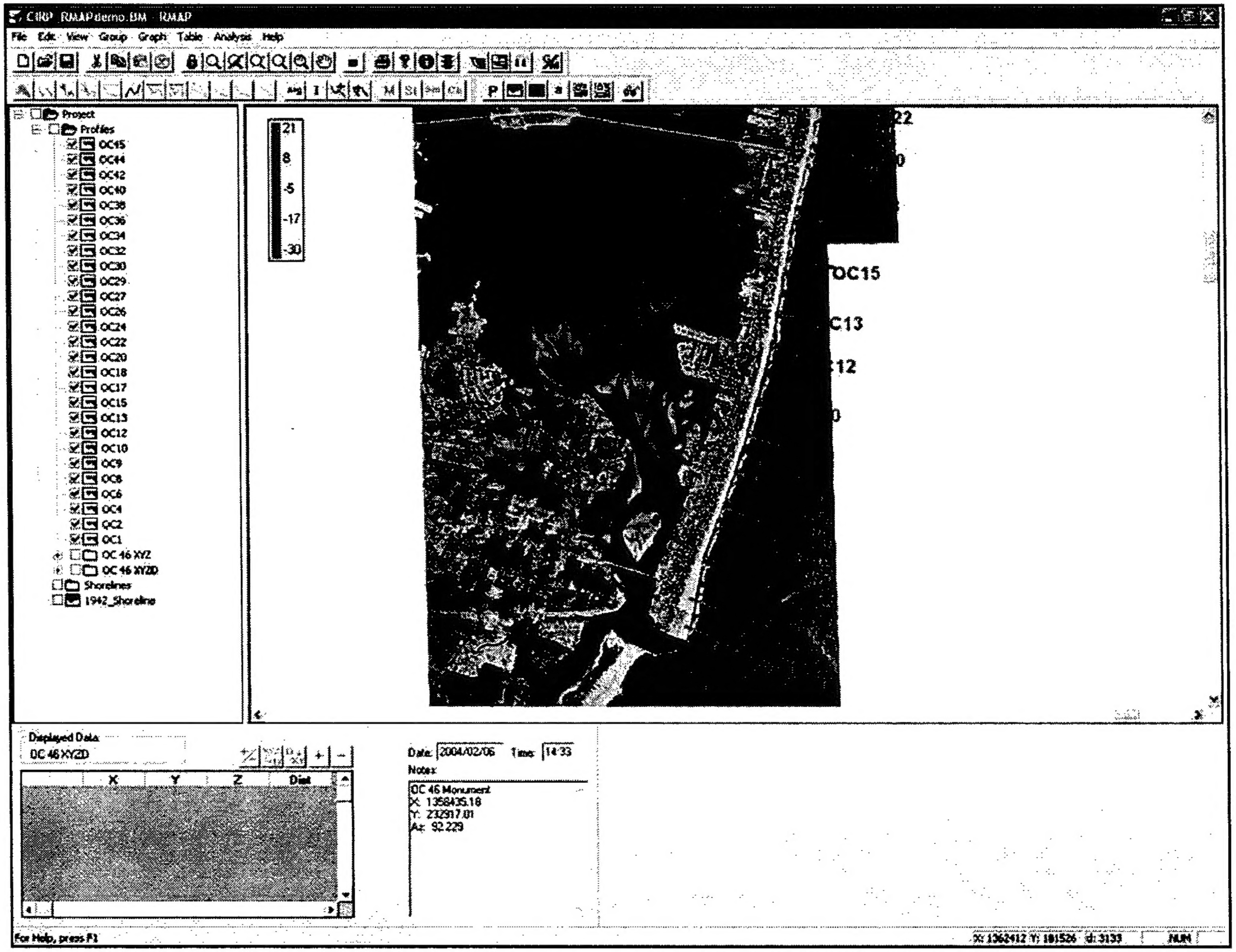


Figure 11. Profile data plotted in map view with georeferenced aerial photography in background

back to text

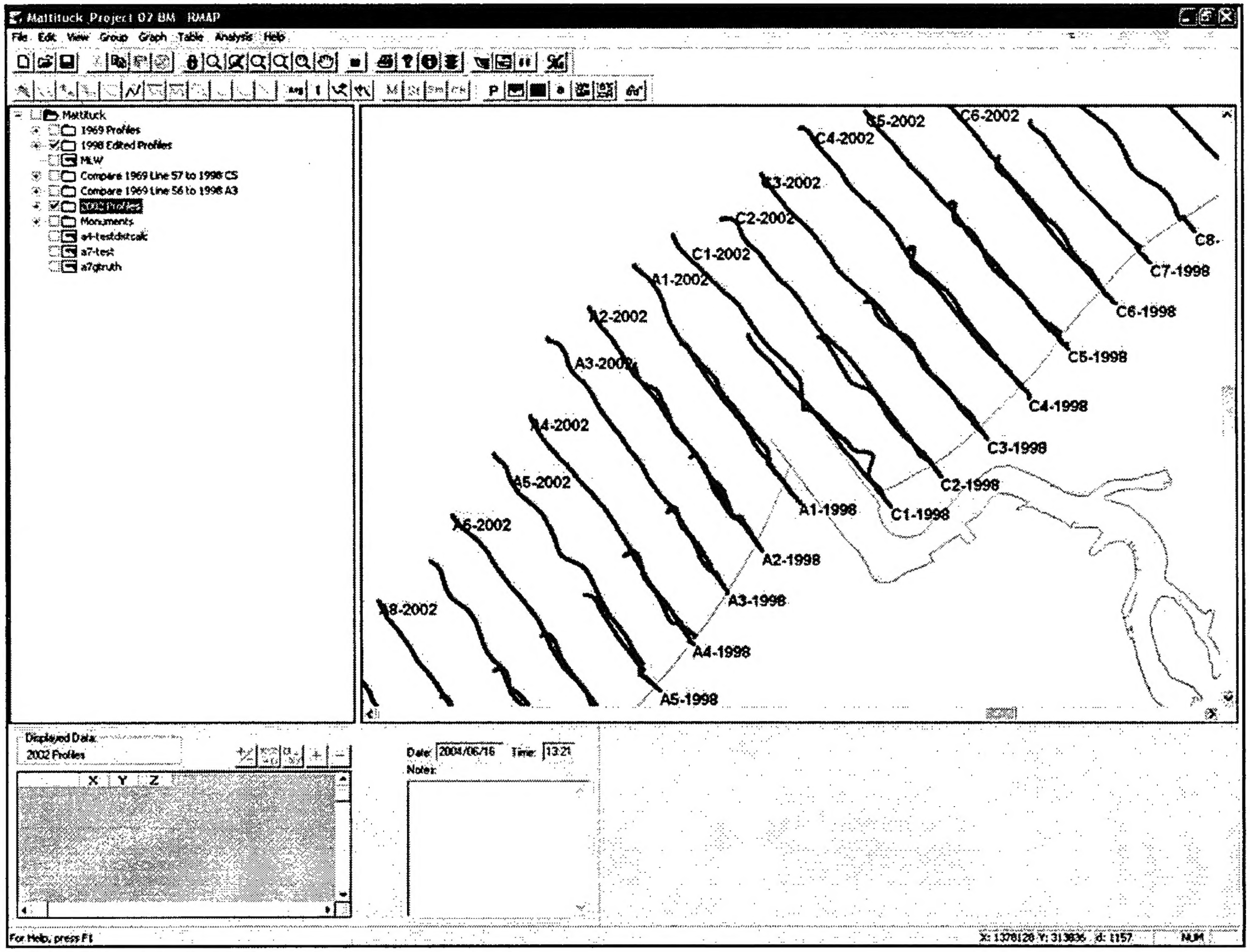


Figure 12. Map view allows investigators to view profile data in plan view, simplifying project data assembly and quality control of successive survey data

back to text

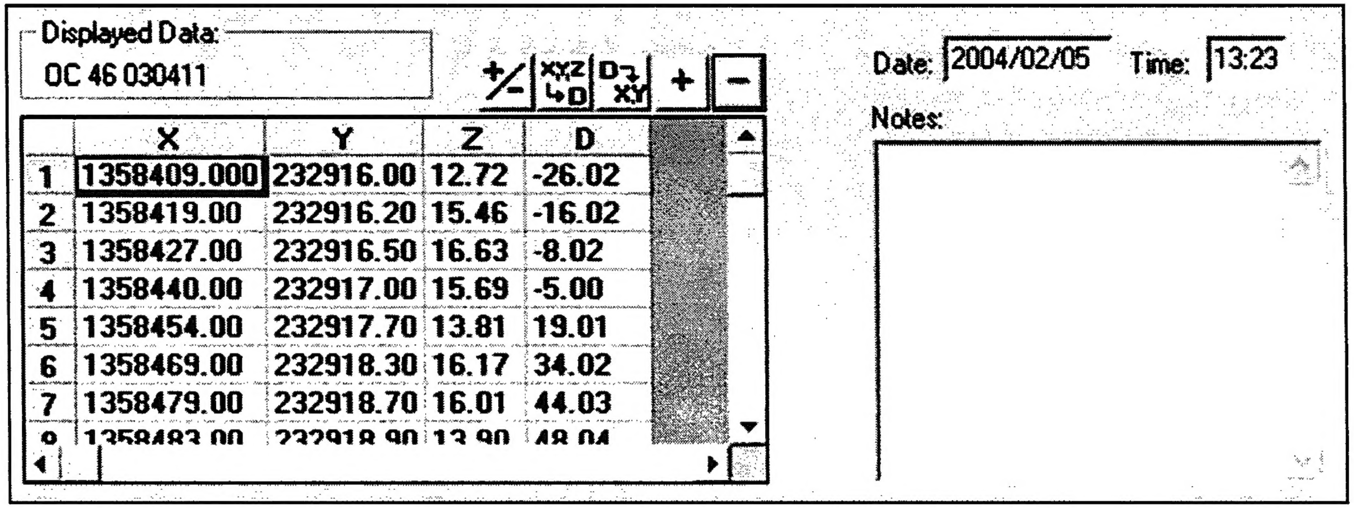


Figure 13. The data table in RMAP allows user to edit items in spreadsheet format and store documentation relating to individual items

back to text